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By Staff, Division of Minerals Health and Safety Technology

UNITED STATES DEPARTMENT OF THE INTERIOR

Pittsburgh Research Center

Information Circular 8817

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UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES
Lindsay D. Norman, Acting Director

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MINERALS HEALTH AND SAFETY IN-HOUSE RESEARCH, DEVELOPMENT, AND DEMONSTRATION IN FISCAL YEAR 1980

by

Staff, Division of Minerals Health and Safety Technology

ABSTRACT

This publication summarizes, for all interested parties, the research, development, and demonstration in-house projects programed by the Bureau of Mines for fiscal year 1980 (October 1, 1979 - September 30, 1980) under its Minerals Health and Safety Research program. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the system technology required to create a healthier and safer working environment for the Nation's mining and minerals processing workers.

INTRODUCTION

The Bureau of Mines conducts a balanced, continuing in-house research and development program to accelerate systematic improvements in health and safety conditions in U.S. mines. This paper outlines the Bureau's present in-house effort to all interested parties; in particular, potential contractors can refer to it when submitting USP's (unsolicited proposals), thus avoiding proposing research that duplicates work being performed by the Bureau.

The projects presented were planned at the beginning of the fiscal year and are subject to change based on emerging priorities and availability of funds. A companion publication, Information Circular 8816, lists contract projects.

PROGRAM OUTLINE

The objective of the Minerals Health and Safety Research program is to protect the health and safety of mining and minerals processing workers while insuring that newly developed technology incorporates health and safety criteria. In achieving this objective, four fundamental and complementary requirements must be considered by the research program, as follows:

1. Contributing to the viability of a basic industry.
2. Sustaining productivity.
3. Allowing for a return on capital investment.
4. Providing material and energy to the public

Since mining and minerals processing involve a highly integrated and interrelated set of functions, the program has been divided into a set of interrelated subprograms, each with goals that will provide systems technology solutions to the problems within the framework of these fundamental requirements. The Minerals Health and Safety Research program is divided into 12 subprogram areas as shown:

Health	Safety
Respirable dust	Fires and explosion prevention
Radiation hazards	Methane control
Noise control	Ground control
Industrial hygiene	Industrial hazards
Ventilation	Post-disaster
	Explosives
	Systems engineering

The objectives of these subprograms are described in the following pages, followed by the planned projects and their corresponding descriptions. The aggregate value of the planned in-house projects is approximately $14 million.

HEALTH

Respirable Dust

Program Objectives: To develop procedures for controlling the respirable mine dusts that still constitute the severest health problem facing the mining industries. To develop and/or improve techniques and equipment to prevent formation of hazardous dust concentrations, and to protect miners against dusty atmospheres.

Fragmentation Control

1. Reduction of Airborne Coal Dust and Increased Machine Efficiency

Objective: Develop background information in support of contract research related to reduction of primary dust generation at the bit/coal interface during cutting. Conduct a series of tests designed to determine the effects of water lubricity at the bit/coal interface on primary dust generation and cutting forces. Define abrasive wear and impact failure for coal cutting bits, and relate wear and bit failure to dust generation.

Control of Generated Dust

2. Control of Respirable Dust by Water Infusion and Other Means of Preconditioning

Objective: Conduct underground evaluations to determine the effectiveness of water infusion for respirable dust control. Particular attention will be given to longwall mining operations in different coal seams. Work will also include evaluation of the physical properties of the coalbed relating to fracture permeability, and porosity.

3. Dust Suppression for Haulage

Objective: Continue to determine the effectiveness of various wetting agents for different types of coals obtained from seams throughout the country. The wetting effectiveness of approximately 100 surfactants will be determined for 100 different coal samples obtained from seams throughout the country. The information and data obtained from the proposed program will result in more effective and economical use of wetting agents in reducing respirable dust.

4. Development of Dust Control Technology for Coal Mines

Objective: Conduct preliminary studies of concepts for improvements in dust control technology for coal mines. Investigate the feasibility of ventilating the face by directing the air discharge from a machine-mounted fan. Investigate the use of machine-mounted scrubber techniques for dust control on longwall faces by scale modeling. Develop and evaluate improved dust control techniques in underground coal mines based on shrouded high pressure sprays.

5. Dust Control Technology for Noncoal Mines

Objective: Conduct preliminary studies leading to development of improved dust control technology for noncoal mines and mineral processing mills. Evaluate the dust control needs of the minerals industry through field visits to various mine and mill sites.

6. Survey of Dust Control Problems

Objective: Initiate the compilation of respirable dust sources and their control problems for mining and minerals processing operations. Assess the extent of controls in use through field surveys of these operations.

Analytical Techniques and Equipment

7. Respirable Dust Measurement Instrumentation Evaluation

Objective: Continue evaluating dust samples and monitors developed by Bureau contractors and others in the laboratory and in mines. Specific instruments to be evaluated include the machine-mounted dust monitors using beta-attenuation, the improved light-scattering dust monitors, and various cascade impactors.

Radiation Hazards

Program Objectives: To develop and provide new and improved measurement instrumentation and control technology for protection of miners from exposure to radon and radon daughters and other nuclear radiation hazards in uranium mines.

Control of Radiation Hazards

1. Radon Control Technology

Objective: Continue to develop radon control technology for use in uranium and other mines by investigating the engineering feasibility and cost effectiveness of using sealants, bulkheads, pressure control, tailings backfill, and moisture control in preventing or reducing radon leakage into the fresh airways. These studies will be exploratory in nature. Evaluations of radon control techniques will be conducted primarily in the laboratory with limited in-mine testing of the most promising methods for the purpose of developing sound engineering guidelines for future full-scale development, in-mine testing, and demonstration.

2. Control of Radiation Hazards Through Air Cleaning

Objective: Continue research on the use of air-cleaning techniques for removal of radon daughters from underground mine atmospheres. Determine efficiencies, filter life with regard to moisture and airborne particle size, and concentration and characteristics of the radioactive components of the filtered air. Provide necessary technical assistance to the contractor during development and testing phase of a prototype air-cleaning system. The results achieved to date will be documented in a report suitable for use by the mining and air-cleaning industry.

Radiation Instrumentation and Measurement

3. Electric Radon Daughter Personal Dosimeter

Objective: Continue development of a small, solid-state instrument that will record the daily working level-hour (WL-HR) exposure of a man exposed to radon daughter contamination. Conduct laboratory and field testing of modified dosimeters. Provide technical support during the duration of field study of the electronic dosimeter. Review and analyze the field data and make necessary modifications based on results of filed testing. Continue investigation of new pumps in the laboratory and field. Investigate the feasibility of using a new hybrid radiation detector in lieu of current type and determine the research needs required to introduce such a detector into the current dosimeter system.

4. Personal Exposure Instrumentation and Measurement Technology

Objective: Continue laboratory and field studies on instrumentation for exposure measurements and methods of making exposure measurements related to the miner's exposure to nuclear radiation hazards, with emphasis on the measurement of radon daughter products. Areas to be covered include (a) personal dosimeters, (b) area monitors, (c) shift monitors, (d) long-lived radio-nuclides in mine air. Provide assistance during field testing of dosimeters to verify previously established

accuracy of instruments under test. Continue with the ultimate objective of improving the accuracy and reliability of the current TL dosimeter system. Prepare a detailed report documenting the inhouse research on the TL dosimeter.

5. Radiation Warning System for Uranium Mines

Objective: Demonstrate in three different mines an automated radiation warning system that alerts mine personnel of excessively high concentrations of airborne radiation and, if necessary, to modify the warning system to improve its operation. Construct other sensors to monitor surface and auxilary fan operation airlock doors, and other environmental parameters. All existing Bureau technology shall be considered in development of these control sensors.

Test Facilities

6. Lease and Operate the Twilight Mine

Objective: Continue to operate and maintain an underground uranium mine as a test facility to provide typical mine environmental conditions for research and development studies conducted by the Bureau of Mines, the Mine Safety and Health Administration (MSHA), other Government agencies, and outside contractors in the area of radiation hazards.

Noise Control

Program Objectives: To identify noise sources in underground and surface mines and in related mineral cleaning and preparation facilities, and to abate these noise sources sufficiently to meet Federal noise exposure standards.

1. Assessment of Noise Control Techniques for Coal Mining Machinery

Objective: Continue work on abatement of noise from pnuematic rock drills and drill jumbos through development of shielding and damping techniques for drill steel. Continue evaluation of quiet, preproduction stoper drill delivered under contract. Initiate work involving field evaluation on quieting the Jeffrey 100-L auger miner cutterhead. Emphasis will be placed on transferring the results of successful noise control research projects to MSHA and the mining industry.

Industrial Hygiene

Program Objectives: To identify and control the health hazards created in underground mines and in minerals processing plants by toxic gases and fumes, and by certain particulates produced by explosives and combustibles and by diesel engines. To develop new instrumentation for monitoring toxic components of the underground environment and evaluate commercially available instrumentation. To develop and/or refine analytical techniques for characterizing and measuring toxic components, and to investigate methods for controlling the formation and accumulation of toxic products.

Toxic Gases and Materials

1. Toxic Fumes From Explosives

Objective: Develop, improve, and apply methods of measuring toxic fumes produced by explosives used in underground mining. Evaluate different types of commercial mining explosives and new formulations designed to reduce toxic fumes. Establish relationship between the volumes of fumes produced under actual mining conditions and laboratory test equipment. In addition, establish procedures for measuring suspected toxic gases from explosives and blasting agents other than those toxic products currently being measured for the purpose of fume classification. Eventually, the research should lead to the perfection and semiautomation of mine air sampling procedures and the establishment of new standards for fume measurement, as well as new fume standards for underground mines.

2. Development of Procedures and Equipment To Protect Welders From Fumes on Draglines and Stripping Shovels

Objective: Develop procedures and equipment to protect welders from fumes on draglines and stripping shovels during repair and maintenance operations. This project will investigate the methods and techniques used in welding as well as the equipment used to insure that the work areas inside the large shovel tubs and structures are free of welding fumes.

3. Improved Instruments for Mine Gases and Fumes Found in Mineral Processing Plants

Objective: Evaluate and verify the performance of commercially available and contract-developed dosimeters for toxic and noxious gases found in the mine environment and in confined areas of minerals processing plants. A small colormetric dosimeter is under development to improve its readout efficiency. As required, evaluations of commercial devices will be undertaken. Investigate effects of temperature, relative humidity, and interferent gases on gas sampling and detection.

4. Evaluation of Industrial Hygiene Instrumentation and Equipment

Objective: Continue development and testing of small, simple, prototype gas detector devices, systems, and exposure indicators for toxic gases. This work will include testing of commercially developed equipment as well as inhouse developments. The purpose is to evaluate the workplace environment through timely, meaningful measurement. Personal exposure meters will provide useful logs to document conditions over long periods of time. Demonstration devices developed under this program will be provided to industry and MSHA for field testing and evaluation.

Diesels

5. Control of Diesel Exhaust Contaminants

Objective: Determine the effectiveness of absorbents, catalysts, and scrubbers in reducing levels of contaminant gases and particulates from diesel engine exhaust. Relate emission levels to ambient levels of toxicants in mines. Investigate both single and tandem controls to reduce the levels of particulates and other contaminants. Selected effective analytical methods for acrolein, sulfates, and other toxicants that are difficult to analyze.

6. Development of Alarm Systems for Engines Operated Underground and In Confined Spaces

Objective: Provide increased safety to the diesel vehicle operator through continuous monitoring of ambient CO_2 levels onboard the vehicle by having a warning indication at moderate levels and an automatic vehicle shutdown if an unacceptable level is sustained. Field tests on about 20 alarms from Beckman and/or Andros will continue under Bureau and MSHA supervision.

7. Investigation of Emission Controls for Large Turbocharged Diesel Engines Operated Underground and in Confined Spaces

Objectives: Determine the potentially feasible methods and hardware available and applicable for use as emission and temperature controls on turbocharged diesel engines. The work will continue to review all available literature and to contact experts in appropriate fields of the automotive industry, diesel engine manufacturing, mine equipment manufacturing, MSHA, and the Environmental Protection Agency to provide a basis for future research. The goal is to establish methods of operation and emission control hardware to insure the safe operation of diesels in underground mines and in confined areas found in minerals processing plants.

Ventilation

Program Objective: To develop ventilation systems required to maintain a safe and healthful atmosphere conducive to efficient work output in noncoal mines.

1. Development of Improved Ventilation Technology for Noncoal Mines

Objective: Assess the problems with insulation for cooling water transmission lines in hot noncoal mines. Conduct preliminary studies of the use of water power turbines to pump used cooling water from hot noncoal mines. Investigate the effectiveness of ventilation systems used in noncoal mines having large airways.

Safety

Fires and Explosion Prevention

Program Objectives: To reduce the potential for fires and explosions in mineral extraction and minerals processing operations; to minimize the danger to people on account of fires and explosions that do occur.

Ignition Research

1. Spontaneous Heating of Mine Combustibles

Objective: Investigate the CO formation and spontaneous heating hazard of U.S. coals and develop guidlines for identifying this hazard in the field. Extend spontaneous heating tests and desorption experiments to lower ranked Western coals to correlate their self-heating rates with oxidation and gas emission rates in air at various temperatures. Obtain similar data for other coals and mine combustibles of interest. Examine the surface properties of coals that are highly susceptible to self-heating.

2. Bit Impact Ignition of Methane

Objective: Relate bit wear patterns for point attack bits to methane ignition for various impact speeds on inclusions. A scaled-down rotary head section will be used for impacting point attack bits on inclusions at various sumping rates and/or bit loads. The project will provide guidelines on wear and velocity on the incidence of methane ignitions.

3. Thermal Ignition of Coal Dust

Objective: Construct and operate a furnace suitable for examining coal dust ignition temperatures, combustion characteristics, and the effect of extinguishing agents on these parameters. Determine furnace ignition temperatures as a function of coal dust concentration, coal volatility, and coal particle size. Measurements will include delay time to ignition, flame temperature, and flame product gas analysis. Examine single coal-particle reaction to determine the site of ignition and combustion.

Flame Propagation

4. Physical Description of a Coal Mine Explosion

Objective: Continue investigation into the detailed machanisms of coal dust explosion intitiation, propagation, and suppression, including fluid dynamic phenomena, in single and double-entry mines. Develop sophisticated and rugged instruments to measure dynamic pressure, wind velocity, concentrations of gas and dust, and temperatures in full-scale explosions. Assistance will be provided for the general instrumentation of the Experimental Mine facility, as well as to the various projects using this facility. Design a new experimental mine facility in a remote location so that a wider range of explosions can be examined without disturbing residential neighbors.

5. Flammability of Coal Mine Combustibles

Objective: Develop improved laboratory-scale flammability tests to update MSHA Schedule test methods and evaluate flammability hazard of mine combustibles. Apply the conveyor belt flame spread test developed previously to brattice cloths, hoses, sealants, coatings, and other mine combustibles. Rate these materials for fire resistance. Develop a test method for determining the flash points of solid combustibles. Evaluate new or existing flammability test methods for reliability as required by MSHA.

6. Flammability of Uniformly Dispersed Coal Dusts

Objective: Determine the lean flammability limits (minimum explosion concentration) of dusts such as coal and oil shale dust. Included will be measurements of the effect of added inhibitor powders, coal volatility, particle size, ignition energy requirements, and optical opacity of the dispersed cloud. Measure the pressure history of the explosions, the residual oxygen concentrations, the flame and dust surface temperatures, the residual volatile content, and the shape and continuity of the combustion wave. Compare results obtained with data from the experimental mine and 6-foot gallery. Analyze and revaluate the enormous body of past literature in this area in the light of recent findings.

7. Flammability of Mine Fire Gas

Objective: Measure the upper and lower flammability limits, in air mixtures of gases produced in mine fires,. Ignite mixtures of hydrogen, carbon monoxide, methane, and air in a 12-foot diameter sphere. Measure flame spread and the rate of pressure rise. Map lean flammable limits, approximate rich limits.

8. Flame Propagation Into a Mine Gob Through Methane Drainage Holes

Objective: Determine the conditions under which flame could propagate into a mine through methane-emitting boreholes. Document demonstrations of flame propagation through boreholes. Determine the probability of lightning as an ignition source. Make recommendations for the design and placement of flame arrestors on boreholes.

9. Hazards of Fires and Explosions in Crude Oil Tunnel Driving Explorations

Objectives: Determine the fire and explosion properties of crude oil in the presence of operating mining equipment and explosions. Define the flammability hazard of the vapor formed in oil mines. Determine the incendivity (ease of ignition) of this vapor. Determine whether there exists permissible explosives for use in the presence of this vapor.

Fire Detection and Alarms

10. Physical Modeling of Mine Timber Fires

Objective: Develop scaling laws for full-scale mine timber fires from laboratory tunnel wood fire models. Design optimal methods for prevention and control of fires in horizontal and sloped roadways. Experiments will provide a quantitative understanding of relevant mine fire parameters and the development of optimal methods of controlling the spread of flame and fumes. Study fires supported by wood linings that simulate mine timber sets to test the validity of scaling concepts.

11. Evaluate Detection Systems for Fires and Explosions

Objective: Detect (sense) conditions that lead to fires or explosions. Evaluate and adapt current sensores to mine use. Develop and construct new detectors to explore and evaluate new methodologies. Study I-R radiation for development of detectors.

12. Rate of Float Dust Formation and Deposition in Operating Coal Mines

Objective: Investigate rate of formation of float dust during various coal mining operations in operating coal mines. Determine formation rates for a variety of coal cutting operations such as ripper, borer, auger, and shearer continuous mining operations. Measure formation rates at transfer points and the rate of deposition of float dust in returns.

Suppression and Extinguishment

13. Mechanism of Methane Flame Suppression

Objective: Determine the chemical and physical processes by which powdered extinguishing agents suppress flames and coal dust explosions. Construct a burner system for stabilizing flames containing coal dust and powdered extinguishing agents. Design, fabricate, and operate sampling systems for gaseous flame species and for dust samples.

14. Sealed Mine Fires

Objective: Develop guidelines for safe reopening of a mine following sealing after a fire. Carry out a series of large scale fire trials in a multiple-entry experimental mine to develop criteria. Study the effects of ventilation. Characterize the fire conditions. Evaluate gas analyzers and fire detection systems proposed for in-mine tests.

15. Passive and Triggered Barrier Systems

Objective: Develop and test passive and triggered barriers for the suppression of methane and coal dust explosions. Determine characteristics and effectiveness of barriers and extinguishants with tests conducted in single-and muliple-entry configurations. Determine optimum deployment of passive barrier systems on belt conveyor roadway for protection against coal dust explosion.

16. Improved Fire Protection Hardware Demonstration of Surface Mine Equipment

Objective: Develop and in-mine test improved automatic fire protection systems for use on surface mining equipment. Monitor protection systems currently installed in mines. Evaluate the response of fire sensors commonly used on surface vehicles.

17. Design Specifications for Combined Explosion-Proof Bulkheads and Water Seals

Objective: Develop specifications for strength and water tightness for bulkheads and seals. Survey current practice and design a prototype bulkhead that is watertight, fireproof, and explosion-proof. Build a prototype bulkhead in the Experimental Mine and test for leakage, drainage, and ability to withstand a coal dust explosion.

18. Develop Criteria and Methods for Determination of Compliance With Respect to Rock Dust in Coal Mines

Objective: Develop criteria and methods for determining compliance with respect to rock dusting regulations in coal mines. Collect information on rock dusting practices. Recommend improved procedures by which MSHA inspectors may determine compliance with inerting regulations.

19. Improve Design of Rock Dust Distribution for Return Airways

Objective: Develop a more reliable and efficient equipment design for distributing inert dust in return aircourses and gob areas.

20. Improved Mine Fire Protection Hardware

Objective: Develop and in-mine test lower cost, more effective vehicle fire protection systems and underground fire sensors. Through cooperative agreements and small purchase contracts, expand the application of Bureau developed fire protection hardware to all classes of mining equipment. This is an ongoing project, with some systems currently undergoing in-mine validation testing.

21. Fire and Explosion Properties of Oil Shale

Objective: Define, by means of large-scale test, the explosibility limit of coarse oil shale dusts and fire spread rates of bulk material. Seek correlations between mine tests and laboratory research. These large-scale tests will provide an assessment of oil shale fire and explosion potential.

Methane Control

Program Objectives: To prevent the formation of flammable methane-air mixtures in underground workings through improved ventilation and procedures for degasifying the coalbed in advance of and during mining. To establish correlations between the geology of the coalbed and its gas content, and to use these to predict methane emission hazards.

Fundamental Factors

1. Influence of Geology on Occurrence and Emission of Methane in Coal Measures

Objective: Continue research to develop accurate methods for predicting methane concentrations in unworked coalbeds by establishing the geological structural conditions. Conduct geologic studies of proposed Bureau of Mines degasification drilling sites and of selected areas in the Book Cliffs coalfield, the Arkoma Basin, and deep Appalachian coalbeds. Determine the effect of greater depths and increased structural complexity on methane emission and degasification techniques. Determine the geologic association of gas reservoirs and source rocks in the Arkoma Basin to provide solutions to mining problems involving migration and retention of gas in the coalbeds. Assess the suitability of computer mapping techniques in predicting geologic trends that influence the occurrence and emission of methane in coalbeds. Continue to refine the direct method for determining the methane content of coalbeds.

2. Prediction of Coalbed Discontinuities

Objective: Define and document the geologic conditions that may control coalbed discontinuities and adversely affect underground mining operations and degasification of coalbeds ahead of mining. Investigate adapting existing statistical and data processing techniques to prediction of coalbed discontinuities and the probability of encountering such hazards at specific locations. Begin the studies on the Beckley coalbed in West Virginia and the Kittanning coalbeds of Pennsylvania, for which a substantial geologic data base has been established.

Control in Advance of Mining

3. Application of Vertical Borehole Degasification to Mine Safety

Objective: Negotiate agreements for draining methane from large acreages of coal property in gassy coalbeds through vertical boreholes in advance of mining. Monitor the resulting contracts, obtain data on the degasification properties of the coals and on gas and water production, and analyze results.

4. Use of Large-Diameter, Multiple-Purpose Borehole for Methane Control

Objective: Continue monitoring methane production at the multipurpose borehole. Conduct methane emission studies periodically in three south mains of the Federal No. 2 mine until the degasified zone is passed. Plug degasification holes before mining intersects them.

5. Use of Air Shafts for Degasification of Coalbeds in Advance of Mining

Objective: Continue monitoring of gas and water production from the degasification holes at the bottom of the air shaft in the Beckley coalbed at the Maple Meadow mine. Plug the holes before their interception by mining.

6. Investigation of Available Equipment for Directional Drilling of Coalbed Degasification Holes

Objective: Test various types of rock to determine the most effective bit design for drilling. Determine from available literature and meetings with engineering and sales personnel of various manufacturers the most effective drill bits, drilling assemblies, and drill pipe for drilling directional holes. Match suitable drilling rigs and mud pumps to the chosen drilling assemblies.

Control During Mining

7. Development of Control Technology Using Horizontal Boreholes

Objective: Continue monitoring gas flows from the horizontal methane drainage holes at the Marianna No. 58 mine. Drill horizontal holes underground at the Beckley and Sunnyside mines and connect to underground piping and monitoring systems. Continue monitoring gas flows from the long horizontal holes drilled to intercept methane migration from virgin coal into the gob at Federal No. 2 mine.

8. Study of Ventilation in Control of Methane

Objective: Acquire European and other types of blowing tube diffusers and evaluate them in underground operating mines. Conduct tests in a mine of Southern Utah Fuel to optimize a 7,000 cfm scrubber exhaust; tests will be made with exhaust primary ventilation and the exhaust duct at distances of 10 feet or greater. Prepare handook on stoppings.

9. Study of the Use of Water Infusion To Control Methane

Objective: Continue studies of problems with horizontal drilling and water infusion at the Jim Walter Resources No. 4 mine in the Mary Lee coalbed. Conduct study of integrating water infusion into the mining cycle in the Freeport coalbed if a site is available.

10. Gob Degasification From Underground Locations

Objective: Monitor the gas flow during formation of the gob from the small-diameter holes that were drilled at various inclinations into the strata overlying a longwall panel at the Virginia Pocahontas No. 2 mine in the Pocahontas No. 3 coalbed. Conduct another test to determine the feasibility of constructing a pipeline that will remain open and intact when used in gob areas to collect and remove methane.

Ground Control

Program Objective: To conceive, develop, demonstrate, and transfer technology that will present mine accidents attributable to falls of ground, outbursts, and slope failures.

Premining Investigations

1. Determination and Support of Geological Conditions Effecting Roof Instability in Underground Mines

Objective: Conduct detailed geologic investigations of the Upper Kittanning coalbed in Somerset County, Pa. The results will be used to define specific geologic factors affecting roof instability in coal mines. Examine roof fall occurrences, define their causative factors, and develop regional geologic information for prediction of hazardous geologic features in the particular area. Ultimately, the geologic information shall be synthesized to produce practical guidelines for design and selection of roof support systems to effectively cope with unstable mine roofs.

2. Acoustic/Electromagnetic Properties of Coal Measure Rocks

Objective: Determine acoustic and electromagnetic properties of coal measure rocks in the major U.S. coalfields. Obtain drill core samples and perform property measurements in the laboratory, including acoustic core logging, dynamic elastic constants, acoustic impedence, attenuation factors, anisotropy coefficients, porosity, permeability, unixial strength, dielectric constant, dissipation factor, and effects of moisture and stress on the compressional wave velocity. Perform field determinations of lithologic and drilling conditions, rock quality, and geophysical logs at each drilling site. Statistically correlate the rock properties, compare the laboratory data with the field data, and identify potential utilization of the test data in geophysical investigations for mine design and hazard detection purposes.

3. Delineation of Abandoned Mine Workings With High-Resolution Seismic Techniques

Objective: Develop high-resolution surface seismic technology for delineating the boundaries of abandoned underground mine workings. Conduct field tests at selected mine sites, some with known abandoned workings and others with suspected abandoned workings, to determine the optimum seismic techniques for delineating the boundaries of the workings. Verify the test results with the known subsurface conditions, or with drilling. Also, conduct frequency response versus signal input tests to establish optimum sensor/source parameters and to complement analytical techniques.

4. Computerized Remote Sensing Techniques for Detection of Potential Hazards in Mine Areas

Objective: Develop computerized data processing and interpretation techniques for detecting potentially hazardous geologic features in mining areas using the remote sensing imagery data made available by the Landsat Satellite. Obtain local and regional information on the subsurface geologic structures represented by the resulting geologic lineaments in selected areas, where other geologic and geophysical delineation of weakened rock underlying surface bodies of water will be conducted under companion contracts. Compare the remote sensing techniques and the overwater seismic survey methods, and incorporate the results of all equipment and detection technique developments, as well as data interpretation, into a report of investigations.

5. Field Tests and Demonstrations of the Improved Redox Shallow Borehole Probe

Objective: Evaluate the usefulness of the Bureau designed, Redox (reduction-oxidation) measurement instrument in detecting hazardous subsurface areas, such as potential subsidence zones, methane pockets, burn area perimeters, and hydrothermal veins. Conduct field tests of the improved Redox borehole probe using shallow drill holes to determine the possibility of developing a quick and simple method for hazard detection from the surface.

6. Quantitative Measurement of the Time-Dependent Structural Behavior of Coal Mine Roof Rocks

Objective: Determine the time-dependent structural behavior of coal mine roof rocks in the laboratory for roof control planning and field implementation. Obtain roof rock samples from selected coal mines in the major U.S. coalfields, prepare test specimens, and perform laboratory testing to determine their porosity, absorption characteristics, and timedependent structural behavior under constant bending stress.

Develop the relationships to express the change of modulus of rigidity with respect to humidity, creep rate, strength reduction with time under various humidity levels, and stabilization period; and establish the relationship between strength variations and humidity fluctuations.

7. Delineation of Abandoned Mine Workings with Microwave Techniques

Objective: Continue development and refinement of microwave radar sounding techniques for detecting and delineating abandoned mine workings and hazardous geologic features in metal and nonmetal mining areas. In conjunction with a companion contract, construct and test focused antenna systems for field applications, both above and below ground. Evaluate a focused antenna presently being improved under Bureau contract and identify its radiation field and interaction with mine voids and faults. Assemble an array of wide-frequency band dipoles for sharper radiation field, and analytically model a synthetic aperture radar radiation mode using field measurement with a currently operational dipole system. Construct and test a wide band antenna assembly for unfocused radiation to maximize target detection throughout the entire rock volume. Fabricate and test optical fiber data transmission lines, and investigate underground data telemetry. Upgrade the data enhancement capability of the present data processing system, measure the frequency-dependent constitutive parameters of rock, and improve the detection capabilities of available radar systems for deeper target resolution and greater range, up to 100 feet and beyond.

Selection of Mining System and Mine Opening Design

8. Coal Mine Single Entry Study

Objective: Determine the structural competence and safety of a single-entry longwall coal mining system. Compare the single-entry system that uses a support-divider wall in the single entry to form a double (head and tail) gate for development and mining of longwall panels with the conventional double-entry or multiple-entry system, and evaluate the single-entry system that uses single entries as single (head or tail) gates. Continue in-mine monitoring of the existing test panels in Sunnyside, Utah, document the test data, develop guidelines for designing single-entry longwall mining panels and roof control plans, and prepare recommendations for the needed changes in health and safety standards and regulations.

9. Application of Ground Control Exploration to the Design of Underground Coal Mines

Objective: Test, evaluate, and demonstrate currently available ground control technologies in mine design and site investigations for their application to the development of new underground coal mines; and develop correlations between the ultrasonic energy transmission

characteristics of mine rocks and the rock stress distributions and other mine design parameters. Conduct dynamic and static core analysis of the core samples obtained from exploration drill holes, and also conduct insitu stress measurements in at least one new underground coal mine. Use the results for actual mine design and planning to evaluate the potential benefit of ground control. Design, fabricate, and evaluate a prototype borehole probe for insitu rock stress measurement based on the principle of ultrasonic birefringence in rock material.

10. Determine Validity of Existing Blasting Proximity Criteria and Vibration Scaling Law

Objective: Determine the validity of previously established damage criteria and vibration levels relative to the proximity of surface blasting operations and underground coal mine openings. In conjunction with companion contract efforts and cooperative programs, acquire pertinent surface blasting and ground vibration data from different mining operations over a wide range of geologic and mining conditions for determination of the maximum variation in the resulting particle velocities in nearby underground mine structures. Compile and analyze the field data relative to amplitude, frequency spectra, geologic enviornment, mine opening configurations, blasting technique and blasting pattern, etc.; and develop a means of predicting safe distances between the surface and underground operations. A properly controlled blasting and measurement program may be used to assess the blasting effects and evaluate the damage criteria.

11. Development and Implementation of Applications Engineering Strategies for Ground Control Research

Objective: Collect and evaluate the products of mining research activities related to specific, real-world problems in the field of coal mine ground control. Define the range of real world problem areas where a need for Bureau assistance in engineering applications of research results exists, and develop the necessary strategies to insure that such assistance and research products are made available to the end users, including mine operators, equipment suppliers, Mine Safety and Health Administration, Office of Surface Mining, and other private and public sectors. The problem areas to be dealt with immediately are (1) collection and use of geologic information to impact mine layout and roof control plan development and (2) applicability of different types of roof bolting hard-ware to various geologic conditions. Based on the recommendations resulting from the companion contract effort in the development of a repository of coal mine ground control data, a program plan for establishing the systematic data collection, storage, and retrieval facility is to be finalized and its implementation initiated. The applications engineering strategies for this project will make use of various vehicles, such as: presentation and publication of technical

papers, delivery of short courses, distribution of educational and training material, conducting open industry briefing and/or work shops, and sponsoring in-mine demonstrations.

12. Operational Guidelines for Stress Measurement

Objective: Improve the use and understanding of a variety of borehole devices for determination of the state of stresses in rock or rock properties. The instruments include vibrating wire stress gage, borehole deformation gage, cylindrical pressure cell, encapsulated borehole pressure cell. Continue to define errors that can be expected from the use of these bore-hole instruments, and establish operational guidelines for proper instruments and assess the errors involving borehole inclusions using the analysis method developed in FY 79; and modify the design of the existing vibrating wire stress gage to improve its performance and accuracy, if practical.

13. Ground Control Manual for Planning Coal Mines

Objective: Produce coal mine design manuals describing procedures that mining companies can follow step-by-step in planning new coal mines to provide safe ground control conditions. Complete and publish the design manual for room-and-pillar coal mines that was previously drafted. Write a second design manual describing: various techniques that may be used to determine structural and physical properties of mine rocks during the initial steps of exploratory drilling, planning, and development of a new coal mine; procedures and theories for designing safe mine openings and mine layouts using the rock properties; and case histories of mine planning and design practices. In conjunction with a companion contract and in cooperation with selected mining companies, develop, test, and demonstrate improved coal mine design techniques and procedures, thus insuring their practicality as well as safety and cost benefits.

14. Design of Longwall Development Entries

Objective: Develop guidelines and procedures for design of two- and three-entry systems for development of longwall mining panels. Compare the relative merits of the two systems regarding ground control aspects, given the structural properties of coal bed and surrounding strata. Continue to evaluate, by field measurements, the ground control performance of the two-and three-entry systems used for developing longwall panels at the York Canyon coal mine of Kaiser Steel Corp. near Raton, N. Mex.; measure pertinent physical and structural properties of the coalbed, roof, and floor strata; and perform structural analyses to establish design and evaluation criteria for the longwall gateroad systems. Assess the effects of longwall face abatement pressures and face convergence on the gateroad stability, and evaluate the structural performance of chain pillars and cribs in the longwall panel during the panel development and retreat mining phases.

15. Prediction and Control of Rock Bursts and Failures in Mines

Objective: Develop effective and reliable methods for predicting rock bursts and controlling burst prone stopes, adn apply these methods to a mine with burst prone stopes for verification of their usefulness in avoiding possible catastrophic structural instabilities. Complete the analyses of microseismic data obtained previously from the Galena Mine of American Smelting and Refining Co., Wallace, Idaho, to identify anomalous microseismic zones prior to rock bursts and to characterize microseismic activity from stressed and destressed zones. Find a new test mine and install instrumentation for rock burst monitoring, if continued monitoring in the Galena Mine is not justified. Investigate the technical and cost benefits of a digital microseismic monitoring system as compared to the present analog systems, and test the inclusion theory of rock failures using the field and laboratory data. Laboratory studies of other parameters, such as the electromagnetic field near the test specimen under loading to failure, will also be conducted with the aim of discovering the parameters that most reliably measure the relative stability of a rock structure.

16. Inherently Safe Mining Method for Rock Bursts

Objective: Demonstrations an underhand cut-and-fill mining method that is inherently safer than the overhand cut-and-fill mining method currently used by some deep mines with a history of rock bursts. In conjunction with a companion contract, efforts will continue to evaluate and demonstrate underhand stoping to control rock bursts in the Coeur d'Alene mining district of northern Idaho. Select a demonstration site, prepare an instrumentation plan, install and monitor the instrumentation, and gather the rock burst data for engineering and safety analysis of the mining method. Discuss the test results with individual mining companies in the district, and determine the feasibility of recommending full-scale applications of the mining method to the mines to reduce rock burst potential.

Roof Support Systems

17. Comparative Laboratory Evaluation of Existing and Innovative Roof Bolt Elements

Objective: Conduct comparative laboratory evaluation of existing and innovative roof bolt elements. Include full column and point anchored resin systems; novel systems such as fiberglass, reinforced resin, and wood-doweled reinforced resin; full column modified resin systems; and imperfectly installed resin systems. Compile a table listing lead versus deflection values in both shear and axial tension.

18. Demonstration of Methods to Control Shear Failure of "Cutter Type" Roof

Objective: Demonstrate methods for controlling shear failure ("cutter-type") and kettlebottoms, in coal mine roofs. Select and examine test sites. Design and install optimum support methods. Monitor resultant roof stability.

19. Load Histories of Longwall Gateroads

Objective: Systematically gather, analyze, and quantify the information of gateroad loading histories in a retreat longwall entry roof supports. Select a minimum of three test sites in underground coal mines, where development of a longwall mining panel is to begin or in process, for instrumentation. Monitor the instruments continuously from the time of their installation until the longwall mining operation ceases in the test area, and analyze the resulting data of gateroad loadings and roof support load characteristics for reevaluation of the effectiveness and adequacy of the roof support systems being use at each test site. Prepare a detailed documentation of the rationale upon which the existing roof support plans were designed and recommend possible improvements to the roof support systems.

20. Inorganic Grouts for Coal Mine Roof Bolts

Objective: Develop and field test two practical systems for installing fully grouted roof bolts with inorganic grouts for coal mines. The two systems to be considered are a cartridge type system and a paste extrusion system.

21. Determination of the Nature and Magnitude of In-Service Loadings on Longwall Face Supports

Objective: Determine the nature and magnitude of in-service loading on longwall face supports. Design and fabricate load-detecting instruments. Develop data collection plan. Begin data collection.

22. Concrete Crib Design and Testing

Objective: Complete the field demonstration and evaluation of concrete cribs. Prepare final project report.

23. Modeling Roof Bolting Systems

Objective: Develop statistically justifiable guidelines for roof reinforcement using mechanically anchored bolts, fully grouted bolts, and friction stabilizers. Compare and then describe the field conditions best suited to each method. Monitor construction of the full-scale roof bolt model system, complete shakedown tests, and establish operating procedures. Initiate test rig utilization, prepare milestone charts, and establish prioritization guidelines for test program--both for full-scale and ¼-scale trials. Establish analytical structural analysis methodology for test rig data utilization. Prepare report detailing utilization plans.

24. Ground Support Systems for Block Cave Mining

Objective: Design and demonstrate improved methods of drift support at grizzly and haulage levels. Expand present test to include one complete grizzly level drift and a 100-foot test length of haulage drift at the San Manuel mine.

25. Longhole Bolting Technique Development

Objective: Develop a new expansion shell for longhole rock bolting for roof stability in metal and nonmetal mines. Conduct preliminary analysis of rock bolting parameters. Fabricate and test prototypes.

Safe Support Installation and Protection at the Face

26. Retreat Mining Methods

Objective: Review and coordinate the results of existing retreat mining contracts. Conduct background and field studies on current retreat mining systems, in coal and metal/nonmetal mines. Incorporate these findings with computer simulation results of various retreat support systems to identify those research areas in retreat mining where a high probability of success might be realized. Define more accurately the various health and safety and production statistics associated with retreat mining. Apply the Underground Materials Handling Simulator to the Retreat Mining Support System previously developed. Collate information gained into a basis for an expanded program in retreat mining methods.

27. Evaluate Support Wall Systems

Objective: Determine the stability characteristics of various pack-wall materials and pack systems in place. Determine standardized tests required to establish materials characteristics, develop test program guidelines to determine the overall performance ranges of a pack, and establish the procedures, by laboratory and in-mine trials, necessary to evaluate pack competence.

28. Determine Effects of Roof Bolt Installation Procedures on Mine Roof Stability

Objective: Determine the effects of roof bolt installation procedures on mine roof stability. Develop suitable procedures for installing roof bolts with preselected bearing plate loads. and develop data collection procedures for evaluation of roof bolt performance and roof behavior. Select test mines, install test panels, monitor the instrumentation, and collect and analyze the field data.

29. Inorganic Grouts for Roof Bolts

Objective: Develop and field test two practical systems for installing fully grouted roof bolts with inorganic grout in metal and nonmetal mines. The two systems to be considered are a cartridge type system and a paste extrusion system.

Hazard Detection and Monitoring Systems

30. Automatic Roof Failure Warning Systems

Objective: Develop a commercially practical, automatic roof fall warning system for use in underground coal mines, based on microseismic monitoring or rock noises. In conjunction with a companion contract, continue field trials of the existing experimental units in selected coal mines to establish a sufficient data base for determining adequate threshold levels and characteristic responses for prediction and warning of impending roof failures. Construct commercial prototype units, based on the designs completed in FY 79, and conducted in-mine testing of their performance under various roof fall conditions in active working places. Also develop data analysis techniques such as fast Fourier transforms to debug and improve the prototype units.

31. Laboratory and Field Study of Roof Failure Prediction in Mines

Objective: Acquire knowledge of microseismic anomalies of mine rock prior to failure so that imminent roof failures in coal mines may be predicted with increased reliability. Determine in the laboratory the

causes of the time variation of microseismic precursory to rock fracture, and apply this knowledge in an operating coal mine for prediction of roof failures. Conduct field tests to investigate the changes in frequency and energy of seismic signals, and to determine the optimum geophone location and mounting procedures for proper detection of microseismic signals. Complete instrumentation in potentially unstable areas of the test mine, monitor one or more roof failures, reduce the collected data with the aid of computer, and analyze the data to define the necessary and sufficient conditions leading to imminent roof failures.

32. Microseismic Monitoring of Coal Mine Entry Systems

Objective: Determine the relative stability of various coal mine entry systems by means of microseismic monitoring. Monitor microseismic activity in the entries of an advancing longwall mining system using a packwall support at the Dutch Creek No. 1 mine of Mine-Continent Coal and Coke Company, Redstone, Colo., and compare the microseismic data with the roof activity information obtainable from conventional instrumentation with strain gages. Reduce and analyze the microseismic and strain gage data taken previously at the Sunnyside No. 1 mine of Kaiser Steel Corp., Sunnyside, Utah, and the data that will be taken at the Dutch Creek No. 1 mine during FY 80, to determine similarity and/or dissimilarity in the structural stability among different longwall gateroad systems, support systems, mining systems, and geologic conditions. In conjunction with related projects in microseismic hazard detection technology, provide imput for the design of a standardized microseismic monitoring system for use by coal mine operators.

33. Coal Mine Bounce and Outburst Studies

Objective: Determine if microseismic techniques can be used to delineate where and when coal mine bounces and coal and gas outbursts are going to occur, and to establish the equipment and technology required for commercial application of these techniques. Effectiveness of coal bounce and outburst control techniques, such as volley firing, will also be evaluated. Continue the ongoing field tests at the Dutch Creek coal mines, Redstone, Colo., to verify the applicability and reliability of the microseismic monitoring system. Monitor two advancing longwall mining panels and one room-and-pillar mining panel. Try digital microseismic techniques to assess their effectiveness and usefulness in continuous collection and computer analysis of the data. Document the test results, and develop guidelines for monitoring and preventing coal bounce and outburst phenomena.

34. Thermal Detection and Prediction of Coal Bumps

Objective: Determine viability of the method for detecting incipient coal bumps based on measurement of the temperature changes caused by increased stresses in rock, and develop inexpensive techniques and equipment for coal bump prediction. Conduct laboratory tests of representative rock samples to measure the physical and thermal properties necessary for this study, such as diffusivity, conductivity, thermal coefficients, compressive strength, and tensile strength. Select a site for full-scale field tests, install the necessary instrumentation at the test site, and measure the temperature changes in coal at potential bump locations. Analyze the laboratory and field data, and evaluate the thermal detection and coal bump detection techniques.

35. Application of Rock Burst Technology

Objective: Assess the positive as well as negative effects of the destressing methods presently used in the Coeur d'Alene mining district, Idaho, on rock burst control in the destressed stope and incidental structural stability problems in the adjacent stopes. Identify the seriousness of their resulting problems, and determine how a mine-wide microseismic monitoring system can best be used to allow mine personnel to assess their destressing program and techniques on a continuing basis. Examine recent improvements in the existing microseismic monitoring system, both hard-ware and software, and determine whether or not more improvements are necessary for commercial applications. Continue ongoing field tests in the Galena mine, and analyze the test data to establish more conclusive evidence on the potential of microseismic prediction of rock bursts. Configure the Automatic Rock Burst Monitor (RBM) as necessary, and provide proof of its rock burst prediction capability. Develop guidelines for rock burst prediction and control in mines.

36. Slope Failure Detection

Objective: Field test and improve a microseismic slope failure detection system that can be used in an open-pit mine to forewarn mine management of impending slope failure so that proper safety precautions can be taken. Continue field monitoring at the Morenci mine of Phelps Dodge Corp., Arizona, using the monitoring system completed in FY 79; and monitor an additional site at the nearby Metcalf mine, if necessary. Incorporate an error analysis program and a new source location program into the existing rock noise analysis program of the monitoring system.

Mining and Minerals Processing Waste Stability

37. Alternatives to Present Coal Waste Disposal Methods

Objective: Develop and demonstrate alternatives to present coal waste disposal methods that will result in safer and more environmentally

acceptable disposal techniques. In conjunction with companion contract efforts in coal waste dewatering and dry fine/coarse waste mixing, determine the most promising method and potential alternative methods of coal sludge dewatering at preparation plants and of mixing fine and coarse waste particles to form a stable waste material for embankment construction. Conduct laboratory tests to study accelerated drainage dewatering techniques and to determine erosion and weathering rates of various types of coal refuse for further investigation into erosion and weathering control methods. Design the optimum dewatering systems, and perform large-scale field tests, in cooperation with selected coal mines.

38. Electrokinetic Consolidation of Coal Sludge

Objective: Demonstrate the technical and economic feasibility of electrokinetic dewatering and consolidation of coal sludge to produce a stable waste material. Continue to conduct the ongoing field tests using the test facility constructed in FY 79 at the Moss No. 3 preparation plant of Clinchfield Coal Co., near Dante, Va., under the existing cooperative agreement with the company. Evaluate the effectiveness and costs of treating old sludge taken from the pond and new sludge directly from the preparation plant. Also, conduct testing with several electrode systems installed in an old impoundment to dewater sludge in place. Document the field test results, and prepare reports and user's manuals for design, operation, and economic assessment of the treatment process and equipment.

39. Factor of Safety/Risk Analysis in Tailings Embankment Design

Objective: Apply operations research and statistical techniques to the design of minerals processing tailings dams. In conjunction with a companion contract effort in probabilistic modeling of tailings embankment design, establish a confidence interval or a level of uncertainty about the values of safety factor computed by traditional design formula. Review, collate, and summarize currently available techniques for computing the factor of safety in tailings dam design; use risk analysis as a decision tool for differentiating between competitive dam designs; and make field examination of tailings embankments to verify the reliability of the embankment structures and their designed safety factor.

Industrial-Type Hazards

Program Objectives: To (1) limit the possibility of human error through training and worker-machine interfacing, (2) improve equipment design and controls, (3) detect and prevent failures of electric circuitry and hardware, (4) provide adequate lighting in working areas, (5) insure continuous and reliable communication between all underground and surface mine personnel, while providing continuous surveillance of the mine environment, and (6) improve safety in haulage and materials-handling operations.

Human Factors

1. Standards for Equipment Design and Investigation of Improved Methods for Conducting Viable Off-the-Job Operator Training

Objective: Develop standards for equipment design that will be used in modification of existing equipment and in the design of new equipment primarily for underground use, and investigate various improved methods for conducting viable off-the-job operation training.

2. Foreign Literature Translation

Objective: Translate selected articles concerning human factors research that are available in foreign literature.

3. Training Strategies To Achieve Effective Learning

Objective: Assemble and evaluate literature pertaining to training strategies and their effectiveness. The project will be coordinated and reviewed with MSHA.

Electrical

4. Specification for Permissible Equipment

Objective: Develop static electricity test for the proposed intrinsic safety regulations, evaluate a computer program for analyzing intrinsically safe circuits, and study pressure piling and its relevancy to mining explosion-proof enclosures. Continue to support MSHA on requested projects and assist Bureau contractors in understanding the requirements for permissible equipment and obtaining MSHA approval of equipment.

5. Electrical Equipment Devices and Systems

Objective: Evaluate commercially available devices and techniques for inspection, fault locating, and protection of electric power systems for applicability to mining. Conduct laboratory and field tests of apparatus and methods developed under contract, including cable fault locaters. Develop novel approaches to mining electrical problems. Sessions including hands-on experience with selected devices and techniques will be conducted for coal mining personnel.

Equipment

6. Equipment Development

Objective: Enlarge and update the surface rail test facility by removing curves; evaluate innovative rail-mounted equipment developed under contract activities; and conduct additional experiments and testing of coupling and automatic brake designs.

7. Development, Testing, and Demonstration of Improved Dragline Cable Removal Equipment and Techniques

Objective: Design and fabricate advanced impact removal fixtures for dragline cable wedge removal. Hydraulic fixtures will also be investigated. Testing of the devices will be performed under laboratory and field conditions.

8. Fire-Resistant Fluid (FRF) Compatibility and Limitations

Objective: Investigate the limitations of fire-resistant fluids as related to safety problems they may cause in hydraulic system components and mining equipment.

9. Inmine Testing of Collision Protection Systems for Large Mobile Mining Equipment

Objective: Develop and inmine test prototype hardware that reduces the vehicle collision hazard in open pit mines. The prototype hardware will be put through inmine testing to develop the ruggedization necessary to insure the instrumentation will withstand the mining environment.

Illumination

10. Mine Illumination

Objective: Evaluate specialized power supplies required to illuminate mining equipment that is energized by sources other than ac or 300-volt dc. Maintain and update the machine-mounted permissible illumination systems in use in the Bruceton Experimental Coal Mine. Investigate the illumination of surface mining equipment.

Nonemergency Communications

11. Performance Standards and Systems Approach to Mine Monitoring

Objective: Develop a goal-oriented systems approach to mine monitoring and develop and evaluate performance standards for monitoring equipment.

12. Development of Underground Communication Systems

Objective: Develop and field evaluate special systems and hardware for the purpose of improving in-mine and surface-to-underground communications.

13. Mine Telemetry and Environmental Surveillance System

Objective: Develop, install, and evaluate environmental monitoring systems for underground metal and nonmetal mines. Continue to develop systems for monitoring environmental conditions in coal mines.

Haulage and Materials Handling

14. Fatigue Testing of Wire Rope

Objective: Conduct fatigue tests that can be used as a basis for wire rope retirement criteria. Conduct fatigue tests on wire rope to determine rope life at different loads and to determine when appropriate safety factors have been met. Recommendations on retirement criteria will be made on the basis of fatigue tests. Data will be used to improve retirement criteria standards, aid users in proper rope selection, aid MSHA safety regulations.

15. Materials Handling Equipment Development

Objective: Investigate methods by which various facets of materials handling activities can be made less human-labor intensive. Particular areas of interest would be the transfer and handling of machine components during maintenance activities, the handling of fall debris, and research in support of contractual efforts in this area. This effort will design and construct prototype devices to minimize the human handling of underground supplies. The devices will be evaluated in operating mines.

16. Disabled Mine Vehicle Safety

Objective: Evaluate the disabled vehicle steering problem. Design, fabricate, and in-mine test a portable hydraulic system prototype for one specific type of large haulage vehicle. Continue to investigate the adaptation of off-the-shelf sleep monitors to monitor driver alterness of large haulage vehicles. This program will also test improved vehicle ladder systems.

17. Improved Materials Handling Systems at Surface Facilities

Objective: Investigate methods of materials handling for surface facilities to make them less human-labor intensive. Identify operations now performed by hand that could be automated to work better and safer. Point out work practices that could be improved or even eliminated. Demonstrate the use of machines to do hazardous tasks presently performed by man.

Post-Disaster

Program Objectives: To develop technology that will (1) enable survivors of a mine disaster to escape from the mine or to continue to survive while awaiting rescue by providing protection against toxic and/or oxygen-deficient atmospheres, (2) aid in the location of miners trapped underground, using seismic and electromagnetic means of communication, and (3) facilitate post-disaster rescue and recovery operations through surface monitoring of conditions underground, emergency communications, and mechanized transport and life-support equipment for mine reentry and rescue operations.

Survival

1. Development of Life Support Technology

Objective: Investigate, evaluate, and futher develop advanced life support technology for use in coal mines for self--rescue and rescue team operations.

Communications

2. Trapped Miner Location and Communication

Objective: Develop emergency detection and location systems for post-disaster rescue efforts, evaluate hardware for same, and provide technical assistance to contractors conducting field test programs.

Explosives

Program Objectives: To assess the problems associated with the safe and effective use of explosives in all types of mining activity; these include fixed explosives, blasting agents, blasting devices, and blasting accessories. To conduct fundamental studies of explosive behavior and apply the results in the development of new technology. To develop new and improved test procedures as new mining methods are introduced and new types of explosives are formulated.

Blasting Agents and Other Hazardous Chemicals

1. Permissible Explosive Evaluation and Research

Objective: Explore and resolve problems associated with safe and effective use of underground coal mine explosives in gassy and dusty mines. The research program will include a study of the causes of misfires and deflagrations occasionally reported for permissible water gels. New formulations prepared by other Bureau personnel will be tested in the gallery; this supportive work is part of an effort to control the incendivity of water gels with chemical additives. Work will include testing new permissibles, field samples, and explosives involved in mine incidents.

2. Development of New Schedule Tests and Standards

Objective: Develop standards for permissible explosives, explosive devices, and blasting accessories, and develop test procedures and basic knowledge of explosive incendivity in support of the standards. Schedules and related tests will be developed for stemming devices and other explosive-actuated devices. The problems of (1) desensitization of water gel explosives by extreme temperatures and (2) dynamic desensitization leading to misfires will be investigated. In addition, the mechanisms if ignition of flammable atmospheres by shot firing will be investigated.

3. Hazards of Explosives and Explosive Devices

Objective: Produce data, supply information, and make recommendations relating to the sensitivity of explosives and initiating devices to impact, friction, thermal, and electrostatic stimuli. Optimum designs for antielectrostatic devices for electric detonators will be developed. Research for an ultrasafe detonator will continue applying results of antielectrostatic studies and incendivity studies from related projects. Sensitivity tests will be conducted in connection with investigations of misfire accidents.

4. Fire Hazards of Explosives and Blasting Agents

Objective: Produce data in support of the development of standards for the storage and handling of explosives and blasting agents. Large-scale (field) burning tests of explosives and blasting agents will be conducted, based on information gathered from laboratory experiments. Laboratory-scale determinations of ignitibility, burning rate, sensitization at elevated temperatures, and tendency to detonate during combustion will be continued for these explosives. Laboratory and field test results will be corretated, in order to provide a set of test procedures and standards for determining tendency to detonate.

5. Develop New Explosive Systems

Objective: Develop safer and more efficient explosives for the mining industry. Evaluate basic sensitization processes in water gel explosives and blasting agents. Examine the effects of chemical species and degree of confinement on incendivity of permissible explosives.

Detonation Phenomena

6. Detonation Growth and Decay Investigation

Objective: Develop, improve, and extend experimental techniques for characterizing explosives, blasting agents, and similar materials with regard to their hazard potential. Mechanisms of the development and decay of explosive reactions in explosives, blasting agents, and similar materials in order to enable the development of tests to provide more reliable indications of their potential hazards.

7. Detonation Theory Development

Objective: Develop, improve and extend mathematical techniques to enable the prediction of hazards of explosives and related articles from their composition, structure, and laboratory tests and determinations. Mathematical coorelations will be derived between those properties of explosives, blasting agents, and other explosive substances which can be measured in the laboratory or calculated from the composition, and those properties which significantly affect safety such as sensitivity, energy release, tendency to deflagration-to-detonation, and incendivity.

Systems Engineering

Program Objectives: To operate and maintain underground research and test facilities for use in testing and demonstrating new procedures and equipment before they are field-tested in commercial mines. To participate processing health and safety standards.

Test Facilities

1. Operation of the Experimental Mine and Safety Research Coal Mine

Objective: Maintain and operate the two mine facilities at Bruceton that are used for coal mine health and safety research problems. The underground mines must be maintained in safe and proper operating condition in order to conduct full-scale experiments on explosives, dust

suppression, roof control, ventilation, fire and explosion prevention and suppression, haulage safety, communications, mine surveillance, and any other facets of coal mine health and safety research.

2. Operation of the Lake Lynn Experimental Test Facility

Objective: Maintain and operate the full-scale underground multiple-entry facility and evaluate the effectiveness of various techniques developed for extinguishing coal dust explosions. Included in the testing are extinguishment hardware, ignition quenching devices, and passive and triggered barriers. These studies provide information on the velocity and length of flames, the velocity and pressure waves in advance of flame front, composition of gases at various stages of explosion, and other physical and chemical phenomena associated with gas and coal dust explosions.

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